

# Near-Real Time Severe Weather Damage Identification Algorithm for Vegetation: Development and Early Results

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Presentation 12.1

User Readiness for New Operational Environmental Satellite Systems

12<sup>th</sup> Annual Symposium on New Generational Operational Environmental Satellite Systems

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New Orleans, Louisiana



Transitioning unique data and research technologies to operations

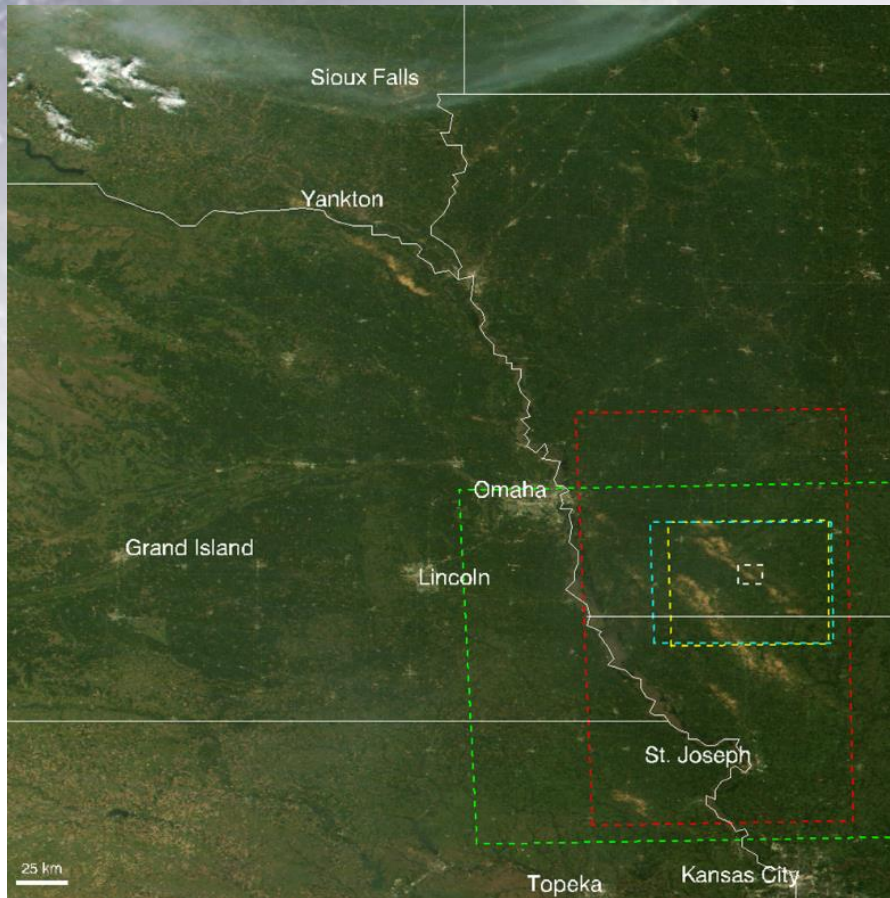
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# Challenge



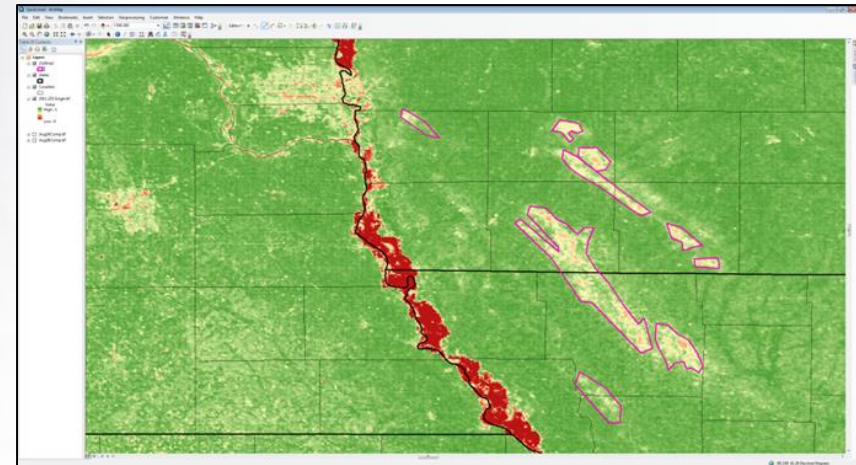
Terra MODIS True Color RGB for 25 August 2011. Reproduced from Molthan et al. 2013.

- Hail storms on average cause more than \$1 billion in damages annually
  - Costliest storm \$1.9 billion in April 2001 (Changnon 2009)
- Hail as small as pea size (0.64 cm, 0.25 in.) can shred backyard gardens to pieces and larger hail size can cause greater damage to agriculture
- Official damage surveys are **NOT** conducted by the National Weather Service
  - Too costly, not enough man power
  - Surveys can take multiple days depending the extent of the damage swath
- **Satellite remote sensing** has been used to identify these areas of damage and analyze the impacts

# Motivation



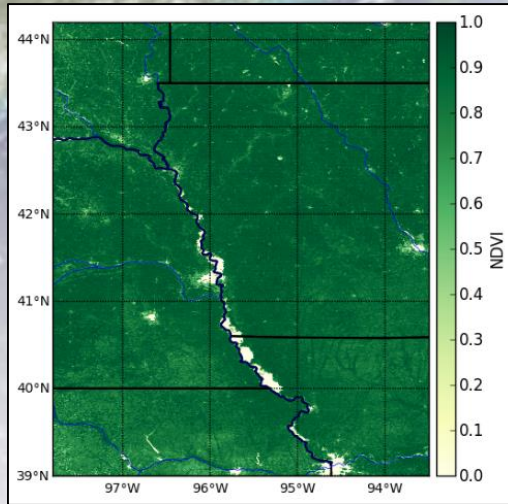
- Previous work has been manual identification of the damaged areas
  - Time-consuming
  - Inefficient
  - Accuracy issues
  - Detract end users and decision makers from completing other tasks



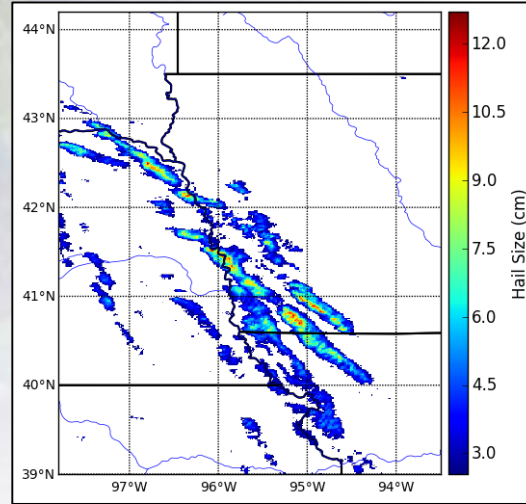
- With costs and personnel concerns being limited, satellite remote sensing data can be used to help fill in gaps in conducting assessments of damage caused by hail
- The effects of hail damage affect more than life and property
  - Impacts on land surface interactions and fluxes, which can be missed in numerical models, with inaccurate vegetation datasets (Parker et al. 2005)
- Advancements in satellite technology (i.e. # of sensors, spatial resolution & temporal resolution) can contribute to the development of **automated algorithms** that can detect damage caused by hail in a **near-real** time setting
  - **Coupled with radar datasets**, the algorithms can be constrained to looking in areas where most likely hail fell



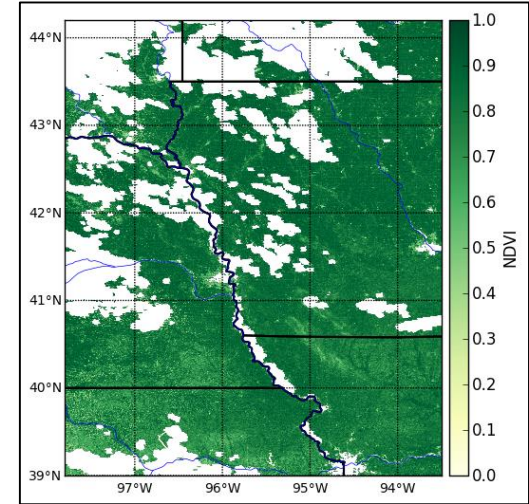
# Technique: NDVI Differencing



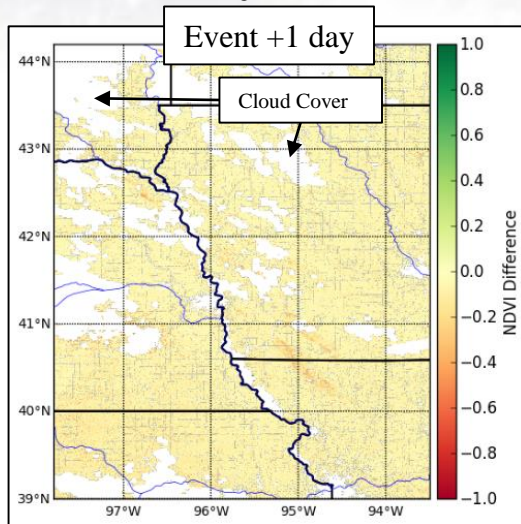
14-day maximum NDVI composite valid for 18 August 2011



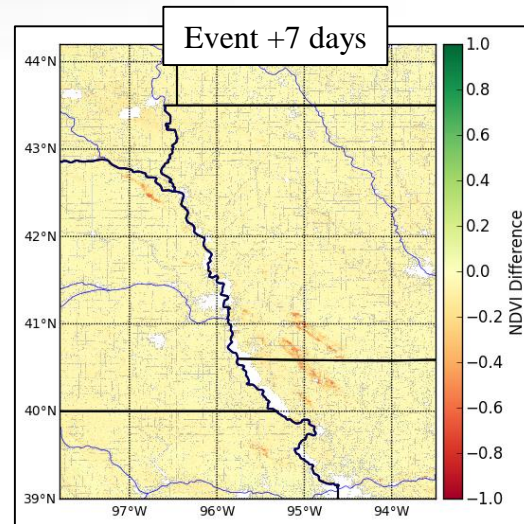
MESH Composite valid from 12 UTC 18 August 2011 to 12 UTC 19 August 2011



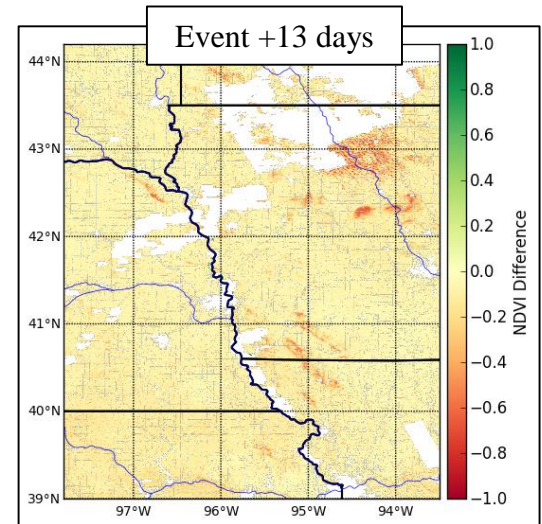
Single day NDVI image valid for 19 August 2011



NDVI difference image valid for 19 August 2011



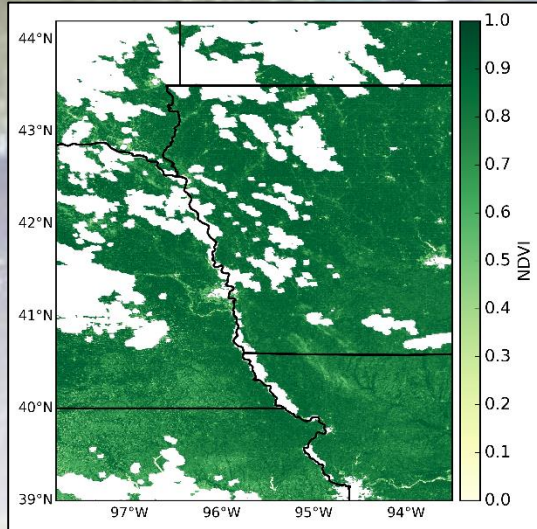
NDVI difference image valid for 25 August 2011



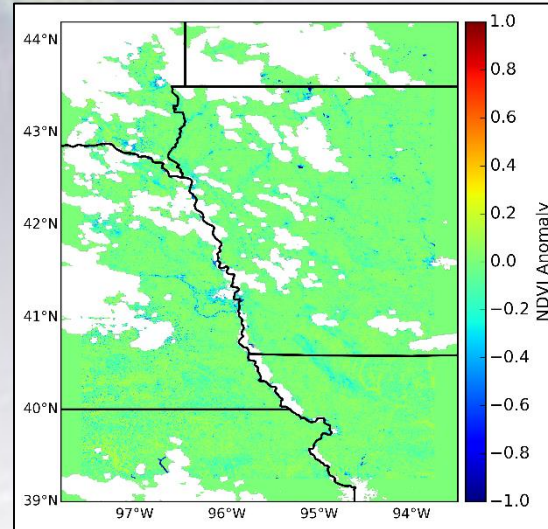
NDVI difference image valid for 31 August 2011



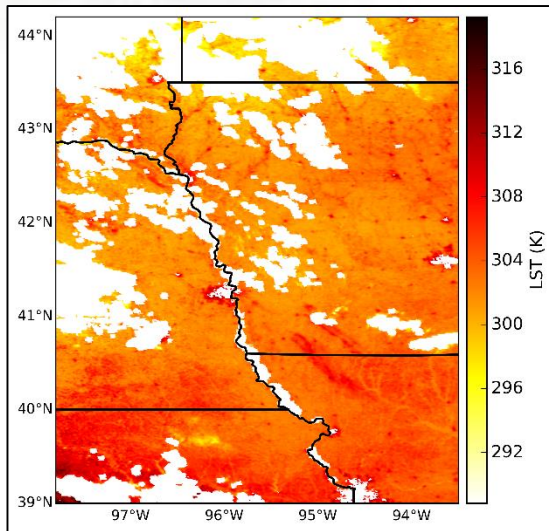
# Technique: Thresholding method



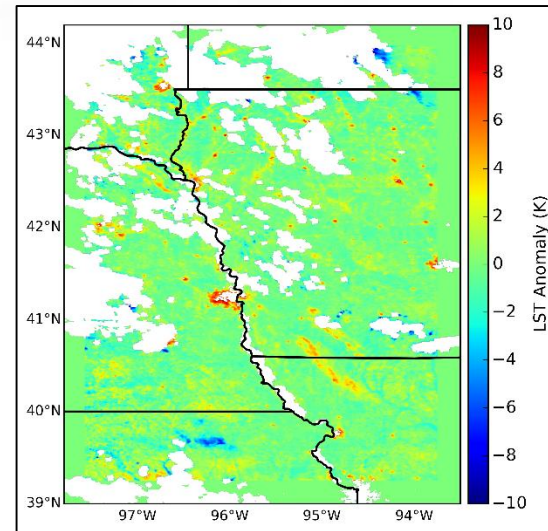
NDVI for 19 August 2011



NDVI Anomaly for 19 August 2011



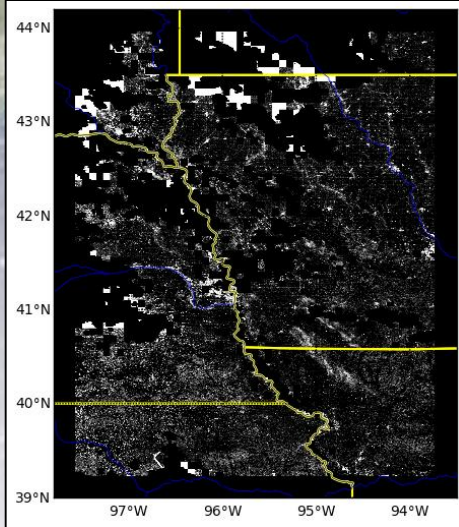
Land Surface Temperature for 19 August 2011



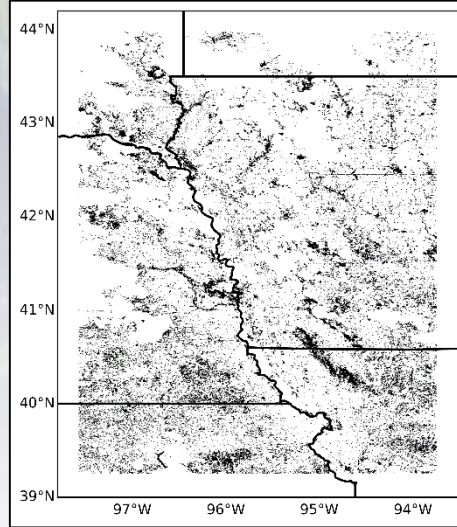
Land Surface Temperature Anomaly for  
19 August 2011

- Anomalies are calculated using a moving box, this helps to rid the image of some noise and identify damage areas where they contrast with the background (lower NDVI, higher LST)
- Kernel Filtering is used to compute anomalies
  - Outer larger box—Median value for all cloud free pixels is determined
  - Inner smaller box—All pixels are compared to median value, with the difference between the two becoming the anomaly
- Images are then converted to gray-scale in order to allow for a grayscale histogram to be created for Otsu's method (Otsu 1975).

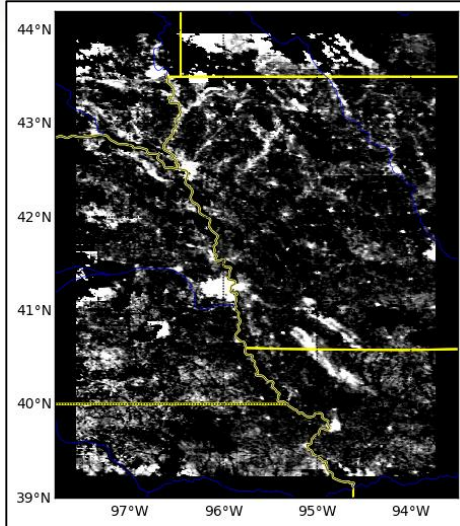
# Technique: Thresholding Method



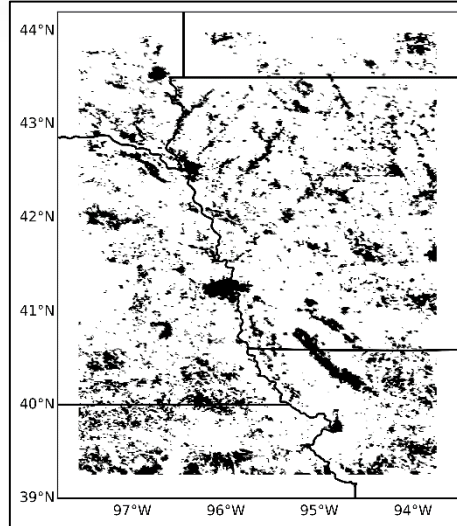
NDVI grayscale for 19 August 2011



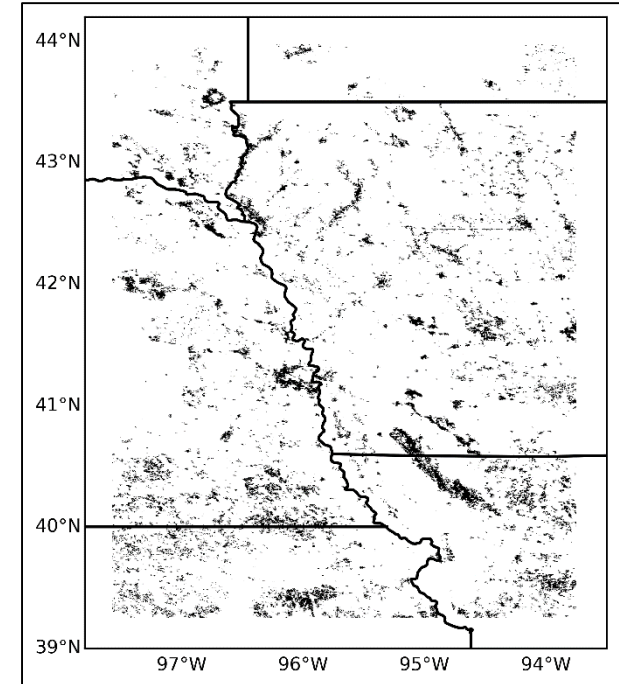
NDVI Otsu Image for 19 August 2011



LST grayscale for 19 August 2011



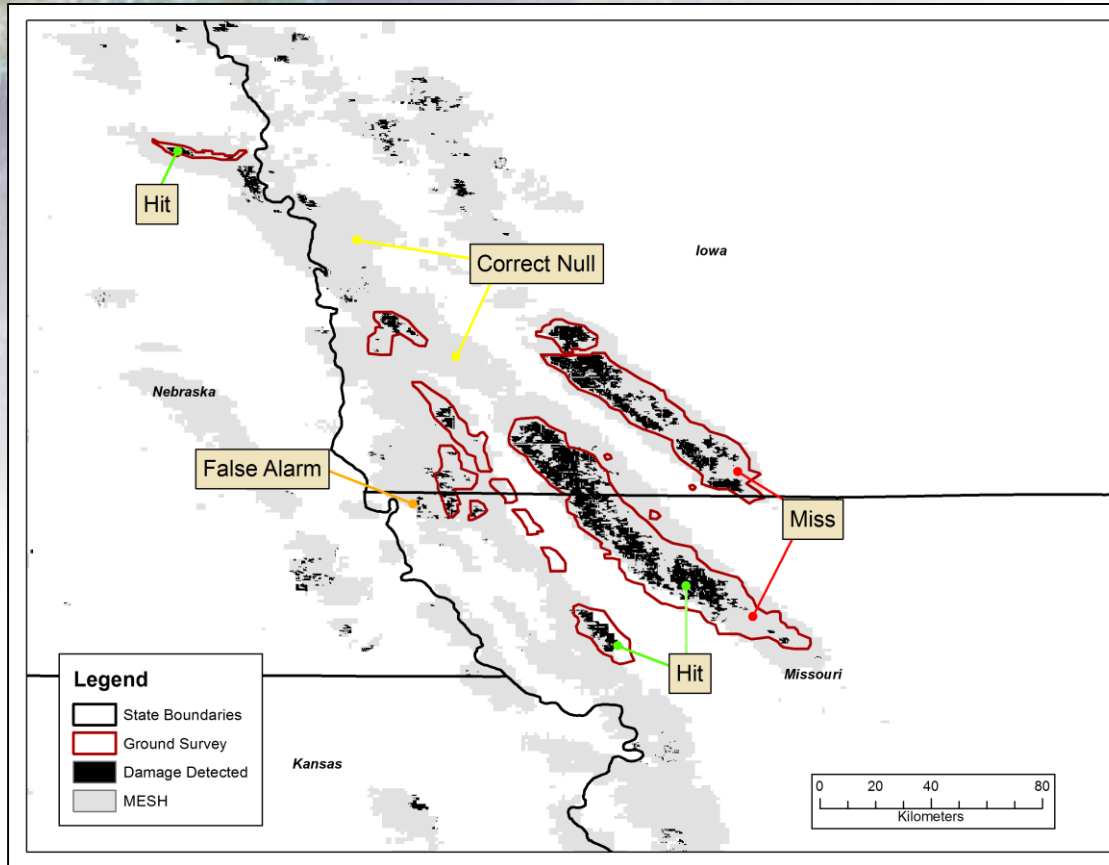
LST Otsu Image for 19 August 2011



Final Otsu200 Image for 19 August 2011



# Measuring Success



31 August 2011 hypothetical damage technique with ground surveys (red) and MESH (washed out)

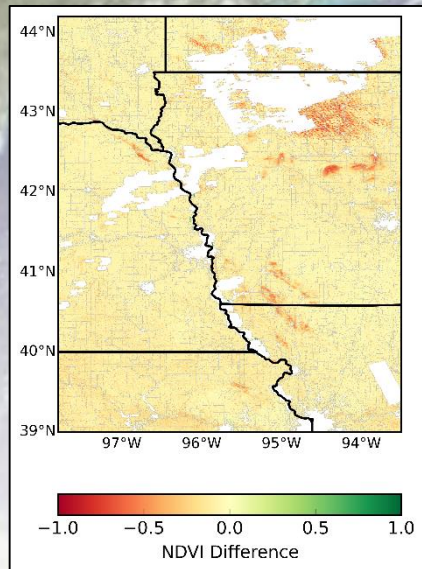
- Satellite derived surveys were created using RGBS
- Skill scores were obtained during three validation periods after the event
  - Short-term: 1-5 days
  - Medium-term: 6-10 days
  - Long-term: 11-15 days
- Evaluation used similar scoring methodology that is used for evaluating severe weather warnings (Schaefer 1990).

$$POD = \frac{Hits}{Hits + Misses}$$

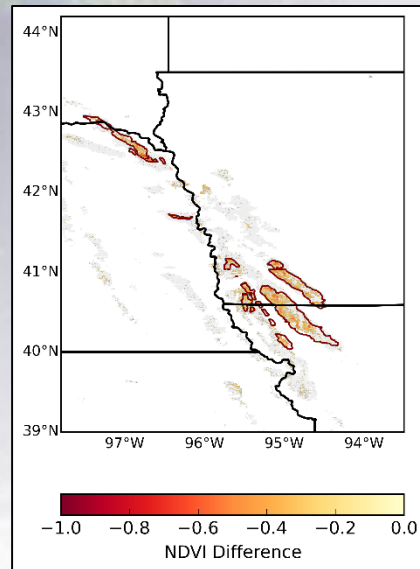
$$FAR = \frac{False\ Alarms}{False\ Alarms + Hits}$$

$$CSI = \frac{Hits}{Hits + Misses + FA}$$

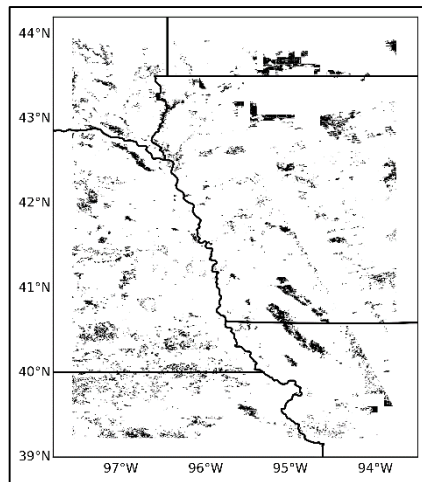
# Event Date: 18 August 2011



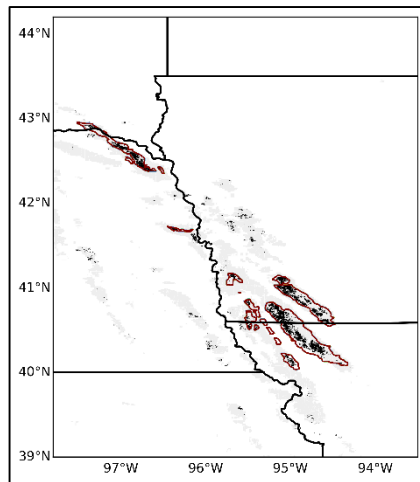
NDVI Difference for 31 August 2011



NDVI Difference validation for 31 August 2011



Thresholding for 31 August 2011



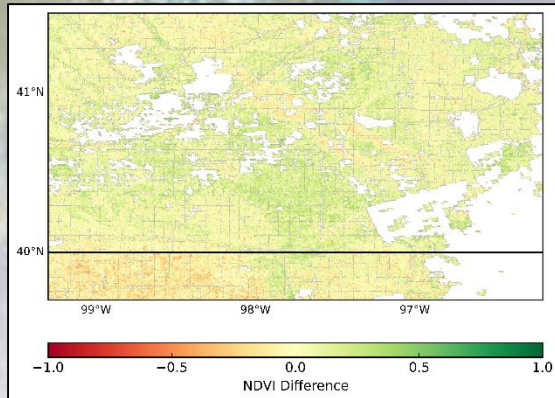
Thresholding validation for 31 August 2011

- Late season growing season case study provided the 'ideal' case study
- POD for both techniques increased in the two weeks following the initial event.
- NDVI Difference had highest POD, but had highest FAR
- Thresholding had increasing POD and lowest FAR

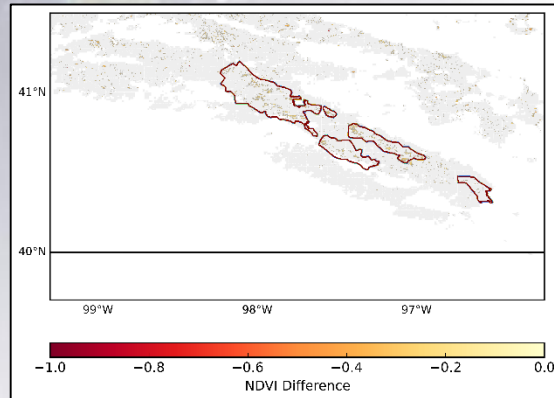
Technique	POD	FAR	CSI
NDVI Differ.	0.497	0.384	0.380
Thresholding	0.338	0.189	0.314



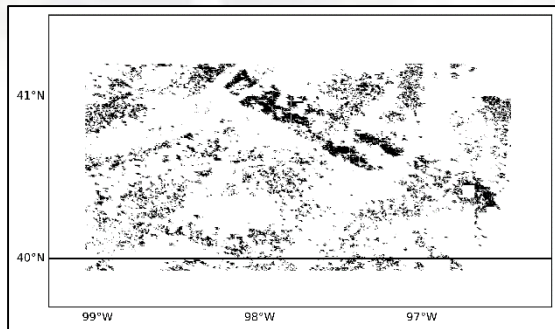
# Event Date: 3 June 2014



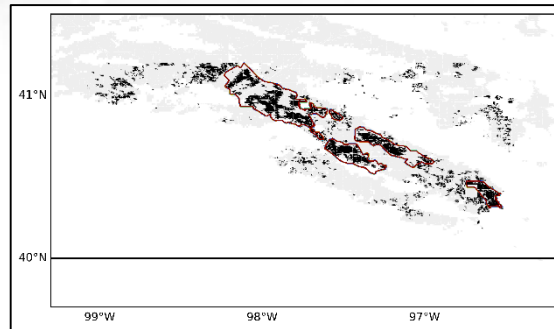
NDVI Difference for 17 June 2014



NDVI Difference validation for 15 July 2014



Thresholding for 17 June 2014

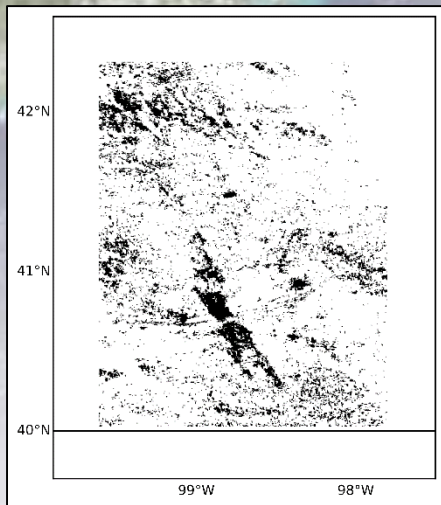


Thresholding validation for 17 June 2014

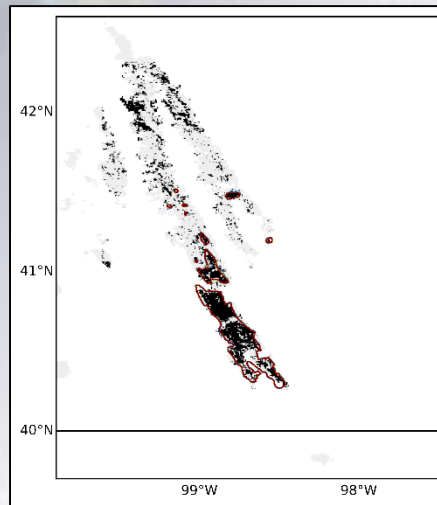
- Early season case showed major differences between two techniques
- NDVI difference technique performed poorly.
  - NDVI actually showed an overall greening in time after the event
- Thresholding was able to see a decrease in FAR and increase in CSI.
  - Calculating anomalies provide success

Technique	POD	FAR	CSI
NDVI Differ.	0.068	0.661	0.060
Thresholding	0.455	0.474	0.322

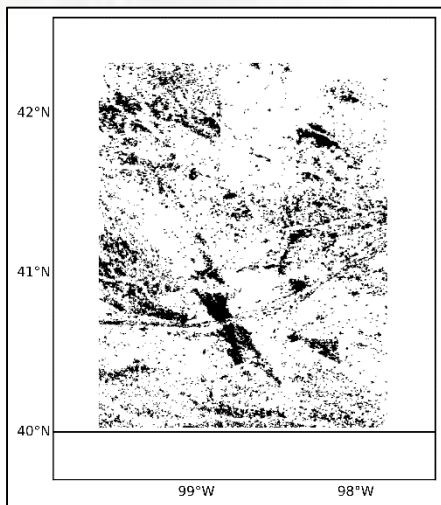
# Further Development



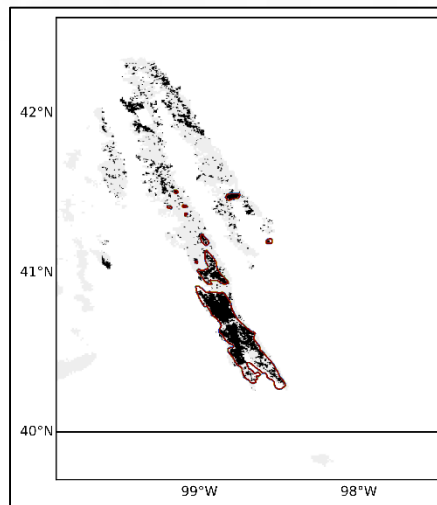
Thresholding for 15 July 2014



Thresholding validation for 15 July 2014



Thresholding for 22 July 2014



Thresholding validation for 22 July 2014

- Selection of threshold technique to be translated to automated near-real time algorithm
  - Relies on single day imagery vs. composites
- All previous case studies have focused on MODIS imagery.
  - Limited number of case studies have occurred during VIIRS era
  - 9 July 2014 case study (left) showed consistent results between MODIS and VIIRS detection
  - Kernels may need to be adjusted for VIIRS data

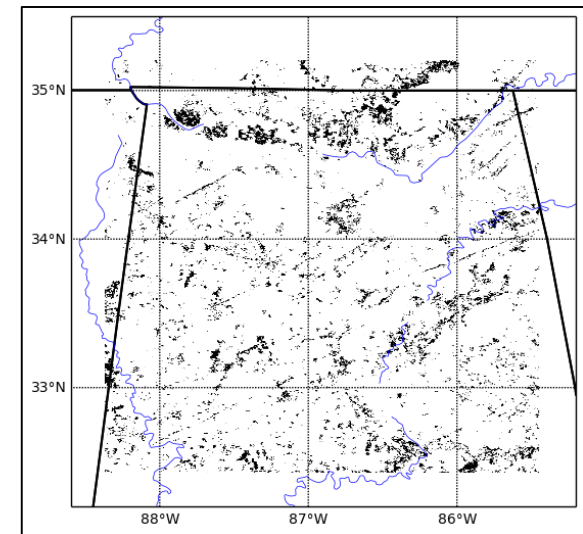
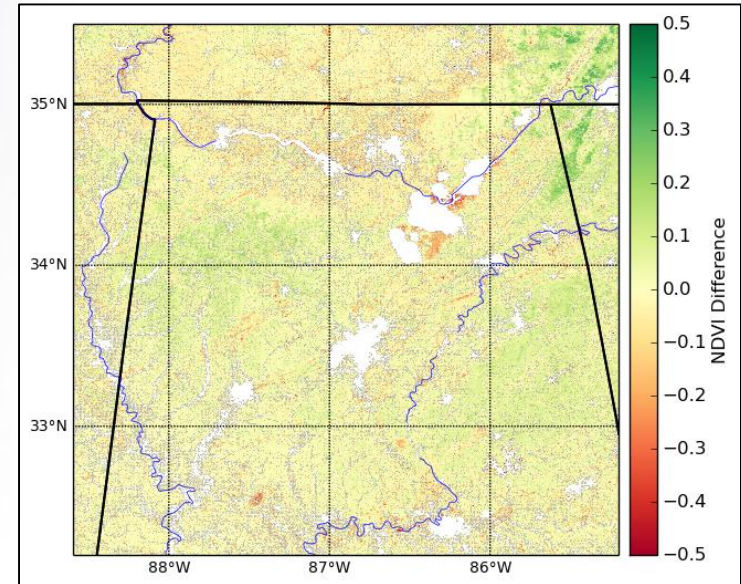
Date	POD	FAR	CSI
15 July 2014	0.623	0.500	0.384
22 July 2014	0.608	0.464	0.398



# Conclusions & Future Work



- Satellite remote sensing has been used in the detection of severe thunderstorm damage to vegetation, but in a time-consuming inefficient manner
- Advancements in satellite technology, coupled with radar derived products can lead to the development of algorithms to detect the damage in a near-real time setting
- NDVI differencing and thresholding technique were very close in performance, but thresholding had the slight edge with it's performance in the early season case study
- Algorithm will be in place for this growing season for evaluation in near-real time setting
  - Continue refining algorithm on VIIRS data
  - Begin testing other severe weather types
    - Tornado tracks



30 April 2011



Questions or Comments?

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- Changnon, S. A., D. Changnon, and S. D. Hilberg, 2009: Hailstorms Across the Nation: An Atlas About Hail and its Damages. Illinois State Water Survey Contract Report 2009-2012, 101 pp. [Available online: <http://www.isws.illinois.edu/pubdoc/CR/ISWSCR2009-12.pdf> ]
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- Schaefer, J. T., 1990: The Critical Success Index as an indicator of warning skill. Wea. Forecasting, 5 (4), 570-575, doi:10.1175/1520-0434(1990)005h0570:TCSIAAi2.0.CO;2.



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